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How stable is Black Carbon? - An incubation experiment

A. Hilscher (1), H. Knicker (1)

(1) Lehrstuhl für Bodenkunde, TU München, Germany

(hilscher@wzw.tum.de / Fax: +49-(0)8161-714466 / Phone : +49-(0)8161-714186)

Black carbon (BC) and black nitrogen (BN) are produced by incomplete combustion of vegetation and occurs ubiquitously in soils. BC has a highly aromatic structure with few functional groups, and is assumed to be relatively resistant to decay. Thus, the charred plant material may play an important role in carbon sequestration. But assuming that biomass burning occurred at the same rate than nowadays since the last glacial maximum, BC should account for 25 to 125% of the total SOM pool (Masiello, 2004). To be able to estimate the recalcitrance of BC in soils, knowledge is required concerning its degradation rates and mechanisms. Therefore, the objectives of this study are to examine the degradation and humification of BC and its transport within the soil profile. A further interest is the impact of addition fresh plant material as co-substrate (CM) on the BC degradation.

The used BC derived from charred residues of rye grass (*Lolium perenne*), which were grown with ^{13}C-labelled CO_2 (99.6 atom%) and with ^{15}N-enriched nutrient solution (KNO_3; 99.4 atom %). After harvesting and drying, the two week old shoots were charred at 350˚C for one (partly burnt) and four minutes (burnt), respectively. The char was put onto a soil column and incubated for up to 18 months at a temperature of 30˚C. The chemical composition of organic matter in the potentially mobile (dissolved organic matter; DOM, and particulate organic matter; POM) and immobilized fractions (mineral associated organic matter of the mineral phase) was investigated by means of solid-state ^{13}C NMR spectra obtained on a Bruker DSX 200 spectrometer using the cross-polarization (CP) magic-angle spinning (MAS) technique. The ^{13}C and ^{15}N contents of the samples were measured with a quadrupole mass spectrometer (QMS) connected to an Elementar Vario EL.

First results shown that after an incubation time of 6 months, 67% to 75% of the ^{13}C input remained in the POM fraction. The ^{15}N recovery for the POM fraction was comparable. The application of fresh plant litter as a co-substrate after four months of incubation resulted in the development of a fungal mat. With respect to the amount of ^{13}C-labeled carbonyl given to the incubate with the fresh partly charred grass, an enrichment (24%) of the carbonyl ^{13}C was observed for the POM fraction, 2 months after co-substrate addition. All other C groups of the POM decreased which is in accordance with a redistribution of isotopically labelled BC into the mineral fractions, DOM and deeper horizons. This affirmed a recovery of 0.2% ^{13}C and 1.5% ^{15}N in the 3 cm deeper sub layer.

Already after one month of incubation 10% of the added ^{13}C was recovered with the mineral phase. After 6 months this amount increased to 27%. Co-substrate addition reinforced this process. We found an increase of up to 39%. The most of ^{13}C from the added char was associated with the clay fraction (61% -75%). This points to the involvement of the minerals in the immobilisation and stabilisation process of char in soil systems. The fixation of the char to the mineral surfaces requires functional groups on the char surface, developed from biotic oxidation of the char.

Our study demonstrates that BC may not be as recalcitrant as commonly assumed. The char material has a high potential to be oxidised. Such oxidized residues are more accessible to microbial degradation and may also be responsible for a more efficient translocation of char into deeper horizons

REFERENCES

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